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Siliceous Sponge Spicules of the Quadrant Formation from Montana.

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A THESIS

Submitted to the Department of Geology, Montana School of Mines, in partial fulfilment of the requirements for the degree of Bachelor of Science in Geological Engineering.

Montana School of Mines

Butte, Montana

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Frontispiece

A corner of the author's laboratory

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INTRODUCTION

The first study of micro-paleontology from Montana to be conducted at the School of Mines started last year. The interest in this work was introduced by Dr. H. W. Scott, and as a result Messrs. Powe and Cubbage of last year's graduating class selected studies in micro-paleontology for their thesis work. Mr. Powe's work was in the form of a survey of the prevalence of micro-fauna in the Paleozoic rocks of Montana. He found that siliceous sponge spicules were present in an upper member of the Quadrant formation from Jefferson Canyon. This interesting find suggested further material for thesis work in a more exhaustive study of these sponge spicules.

The author is indebted to Dr. Scott and Mr. Powe for the material containing the sponge spicules. It was collected by them on a field trip last summer.

The author was unable to find any literature dealing with sponge spicules from Montana, with exception of Mr. Powe's thesis. Although these fossil remnants of sponges have long been known to paleontology, very little work has been done on them and very little literature is available for reference.

No references were found which dealt with laboratory technique aside from that developed by Mr. Powe last year. Thus, part of the problem was to carry on and perfect a technique for handling these delicate specimens.

A sponge spicule is a siliceous or calcareous individual or group of rays which form a framework for the sponge.

The author wishes to thank Dr. Eugene S. Perry, head of the Geology Department of the Montana School of Mines for the valuable assistance rendered him in the preparation of this thesis. In particular he acknowledges the suggestions and instructions given him by Dr. H. W. Scott, geology instructor at the Montana School of Mines, under whose immediate supervision the work was carried on.

LABORATORY TECHNIQUE

The methods used in obtaining micro-fossils vary considerably with the type of material from which they are to be recovered and the frailness of the fossil obtained.

Sponge spicules are very delicate and easily broken. Only siliceous spicules were obtained by the following method for the acid would dissolve any calcareous spicules which might be present along with the matrix.

The first step was to get the spicules out of the

rock. The most satisfactory method was found to be accomplished by leaching the material in diluted hydrochloric acid solutions. For this purpose the author found porcelain crocks of about 1500 cc. capacity to be ideal. A watch glass about 8 cm. in diameter was placed

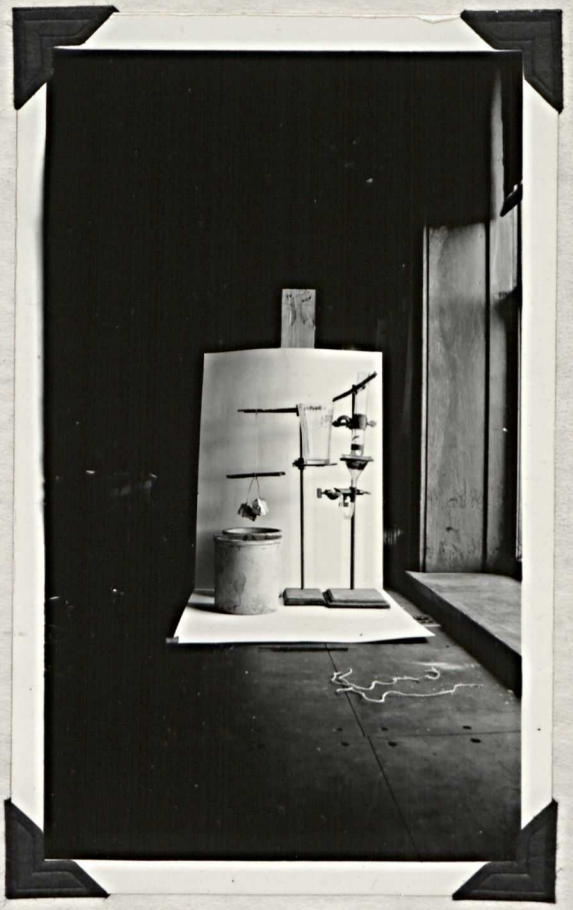


Figure 1
Leaching crocks and elutriator

at the bottom of a crock. Then about 1200 cc. of water were added. The specimens, some of them two or three inches in diameter were suspended in the water by means of copper wire and a stick as shown in the illustration. Then from 15 to 25 cc. of concentrate hydrochloric acid

were added. This would give from one to two per cent concentration and thereby restrict the chemical action so it would not be violent enough to damage the spicules. About three times per day an additional 10 cc's. of acid were added. After three or four days a considerable amount of residue had settled on the water glass. The specimen was then removed and the solution siphoned out of the crock in order not to disturb the residue. The watch glass was taken out and the residue washed in much the same manner as that employed in panning gold. The finest material is quite clay-like and went off in suspension in the water. The product of this operation was washed onto a sheet of paper and dried on the radiator. When perfectly dry, the material was transferred to a glass plate, adopted for microscopic examination, with the aid of a fine camel's hair brush.

The glass plate, size 2" x 3", was prepared for microscopic work by etching with 600 mesh alundum then drawing parallel lines with water-proof ink on the etched surface. These lines were spaced so that one would appear on each side of the microscopic field at a time, thus making it possible to cover the complete field of the plate in a minimum length of time and without missing any part of the area.

The first examination of material brought out two things rather forcibly. First, the washing hadn't been

clean enough and the remaining clayey material acted as a cement, holding the spicules together and causing breakage when attempts to isolate them were made. Second, the successive handling had already broken a very large number.

A number of spicules, however, were obtained from the first trial. A binocular, Bausch & Lamb, microscope with a 17 power objective was found most effective in searching the material for spicules. Upon finding a spicule the material in its vicinity was pushed to one side by means of a pin in the handle of a small camel's hair water color brush. Part of the hair had been removed from the brush in order that it might have a fine point. The tip of the brush was moistened and slipped along the plate and under the spicule. The spicule was then transferred from the brush to a drop of gum tragacanth solution upon a prepared slide. This solution is very valuable as a mounting medium, as it is colorless, dries rapidly, holding the specimen securely in place, and does not discolor the specimen or interfere with photography. If it is desired to remove the specimen or turn it over, a drop of water almost immediately dissolves the tragacanth, freeing the specimen. Sponge spicules are so delicate, however, that after breaking several while attempting to move them, the author decided they were best left as mounted.

The slides were made of strips of one by three inch cardboard. The base had a black surface and upon it was pasted a white strip with about a half inch hole in the center. As the sponge spicules are white they show up to the best advantage on a black surface. The space on the right end of the slide was utilized to draw a sketch of the specimen, while on the left end were printed numbers and classification.

The problem was to figure out a means of mounting the spicules with the least amount of handling from the rock to the slide. A method of elutriation was suggested and with the aid of Dr. Perry, a small elutriator was set up. (See Figure 1) The elutriator was connected to a faucet by means of a rubber tube, and filled nearly to the top with water. Then the residue was washed from the watch glass into the elutriator. Then a very small flow of water was allowed to rise in the elutriator and overflow. This carried over no spicules but did thoroughly clean them of the clay-like cement in about five minutes. The flow was increased slightly and the water caught in ordinary tall drinking glasses. The water was not allowed to drop into the glass but ran down the side in order to handle the spicules as gently as possible. The water was decanted and the spicules washed onto a watch glass where they were dried. Different fractions of sized material was obtained by increasing the flow in the elutriator. In all cases the

material was almost completely eliminated. Breakage from handling is, however, still a problem. After drying upon a watch glass the author gave the material a superficial examination and obtained a large number of specimens which might have been damaged if transferred to the glass plate from which the final examination was made.

It is the opinion of the author that instead of catching the fractions from the elutriator in glasses, they could be caught in shallow glass photographic trays which could be marked for microscopic use and thereby eliminate much of the handling and subsequent breakage of specimens.

After the specimens had been mounted on slides they were filed in a drawer containing notches which held them at about a 60 degree angle, as shown in the frontispiece.

A Leitz Lica camera was used to photograph the specimens. Dr. Scott assisted the author in this work. The camera was mounted on one side of the binocular microscope as shown in Figure 2, and the other side of the binocular was utilized in focusing. A 100 watt light was used, situated about 8 inches from the stage and at about a 45 degree angle to it. Time exposures of from three to nine seconds were taken with the clearest pictures being exposed about five or six seconds. The pictures, if taken direct from the negatives, would be quite small so enlargements were obtained at ten cents

per pictures. These enlargements were then blocked out with black water color, cut out, and pasted on a cardboard for the purpose of photographing as one assembled plate.

Figure 2
Equipment for photographing spicules

In describing the specimens it was necessary to take measurements. This was easily accomplished by use of an ocular micrometer.

The preceding methods of handling siliceous sponge spicules was quite effective, the evidence being the fact that the author's collection contains perfect

specimens of nearly all the species described. No attempt was made to determine the existence of calcareous sponge spicules. If they are present, however, an entirely different technique must be developed to remove them from the matrix as the acid would take them into solution.

DESCRIPTION OF SPECIES

The spicules were leached out of calcareous zones occurring in flinty concretionary forms from a member near the top of the Quadrant formation in Jefferson Canyon, Montana. (See Figures 3 and 4)

Figure 3
Location of Quadrant member
containing sponge spicules.
Jefferson Canyon, Montana

The spicules were undoubtedly composed of siliceous material yet two distinct types were observed. One type was very white and seemed to give much rougher-looking spicules while the other was semitransparent with the spicules appearing rather smooth.

The classification of sponges seems to be rather unsatisfactory, however, we have no other means of taking care of fossil sponges except by the shape of the spicules.

According to Nicholson and Lydekker, "A sponge is a multicellular organism of variable shape, the cells of which are typically disposed to form an outer membrane, an inner membrane, and an intermediate stratum; and which are traversed by canals, which open on the surface, and which are more or less extensively lined by flagellate cells. In most cases the cellular aggregate is supported by a framework of horny fibers, or of flinty or calcareous spicules." When sponges die the organic material

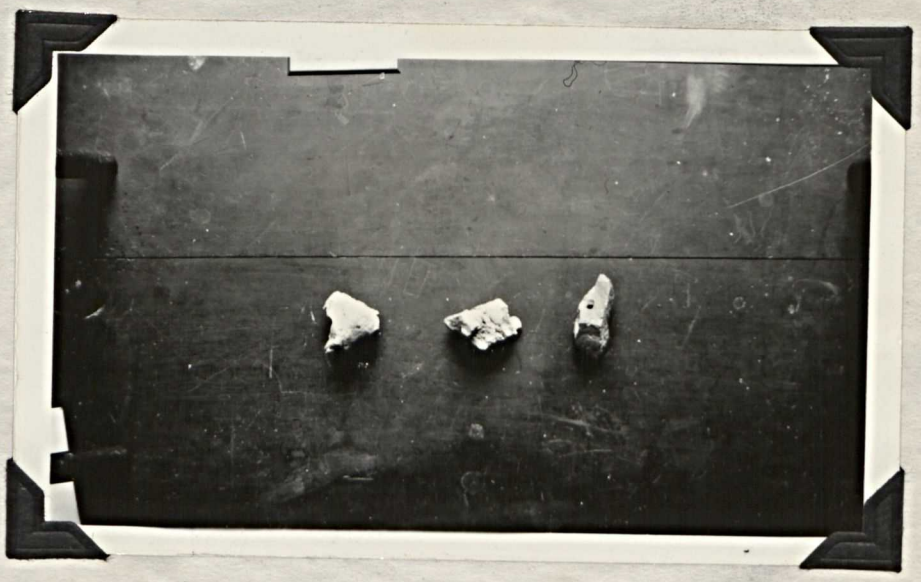


Figure 4
Specimens containing spicules

decomposes and the siliceous and calcareous spicules remain strewn on the bottom. Thus, numerous types of sponges might be represented in a small piece of material. About ninety per cent of the author's collection came from one specimen. (See Figure 4)

The following classification is based on that used by J. Marvin Weller:

Phylum PORIFERA
Class SILICISPONGIA
Order MONACTINELLIDA
Genus RENIERA Schmidt

Reniera is a common form of sponge spicule found in the Carboniferous rocks in many parts of the world. It is classified under this genus because of the close resemblance to the spicules of the modern sponge Reniera.

RENIERA SILIQUA Weller n. sp.

Plate 1, Fig. 1-6

The spicules of this species were cylindrical, uniformly curved, and taper to an acute termination on either end. The specimens observed varied in length from .9 mm. to 2.6 mm. and in thickness from .08 mm. to .1 mm. The surfaces of all spicules are thickly set with minute, equally sized and spaced spines, which are directed at right angles to the spicules.

MSM micro-paleontological collections S1, S2, S3, S4

Genus?

Plate 2, Fig. 12

A type of spicule which was found to be prevalent in the materials studied, consisting of a long slender spine, seems to have been attached by one end and tapered to a more or less acute termination on the other.

These spicules had a rough surface due to numerous minute spines which project at right angles to the spicules. Often the tapering is too small to be noticeable.

The length is from 5 mm. to 7 mm. with a thickness of .2 mm. S3, S4, S5, S6.

Order TETRACTINELLIDA

Genus GEODITES --(Carter)

This group of fossil sponges first appeared in the Carboniferous period. They possess spicules having a long shaft ray with three small summit rays, which closely resemble some skeletal elements of a group of modern sponges. Geodia, is a representation of this modern group, distinguished by features unrecognizable in isolated fossil spicules.

Geodites carbonarius --(Ulrich)

Plate 1, Fig. 6-9, 13, 14

A number of complete specimens of this species were observed. The spicules are covered with numerous very small rays which stick out at right angles to the major rays. The shaft ray gradually tapers to an acute termination. It varies in length from .6 mm. to .96 mm. and is .08 mm. thick. The head rays form an angle between themselves of approximately 90 degrees and vary in length from .12 mm. to .4 mm. They taper rapidly to acute terminations.

MSM micro-paleontological collections S7, S8, S9

Geodites? bifurcatus

Plate 1, Fig. 9, 10

Only one specimen of this type was observed. A question of classification arises because the shaft ray,

if there was one, is broken off. The head rays form an angle with each other that is greater than 90 degrees. They are .2 mm. long from their junction to the point of bifurcation and .1 mm. thick. The furcations which are short and irregular are all bluntly terminated. The surface is covered with minute rays projecting at right angles to the spicule.

MSM micro-paleontological collections S10

Geodites n. sp. --(proposed)

Plate 1, Fig. 11, 12, 15-20

The head rays of this species branch from the shaft ray almost at right angles and then are slightly recurved. They vary in length from .1 mm. to .6 mm. and in thickness at the base from .04 mm. to .12 mm. and taper to sharp terminations. The shaft ray is straight, tapering gradually to a sharp point. It varies from .28 mm. to .4 mm. in length and from .04 mm. to .12 mm. at its thickest section. Numerous fine rays project at right angles from the surface of the spicules.

MSM micro-paleontological collections S11, S12, S13, S14, S15, S16, S17, S24

Geodites n. sp. --(Powe)

The three head rays of this species form an angle of about 45 degrees with the shaft ray. They are slightly incurved and taper to sharp terminations. The length of the head rays in the single specimen observed was .16 mm. and the thickness at the base .02 mm. The shaft ray is

straight, tapering back from the junction of the head rays to a medium sharp termination. It is .48 mm. long and .06 mm. thick at the junction. The spicule is covered with numerous fine, bluntly terminated spines which project at right angles from its surface.

MSM micro-paleontological collections S19

New Genus --(Suggested by author)

A new genus is suggested which is to include those sponges having four equally spaced, equally sized rays.

New Genus n. sp.

Only one complete specimen of this species was obtained. The four equal rays form angles of 120 degrees with each other and taper uniformly to sharply pointed terminations. They are .2 mm. in length and .06 mm. thick at the junction. The spicule is covered with numerous minute rays which project at right angles.

MSMmicro-paleontological collections S18

New Genus n. sp.

Plate 1 , Fig. 20, 24

In this species, after extending about .08 mm. from the junction, each ray trifurcates. The angle formed between the ray and the summit rays is 135 degrees. The summit rays are .12 mm. long and taper from .06 mm. thick at the junction to sharply pointed terminations. Numerous minute rays project at right angles from the surface of the spicule.

MSM micro-paleontological collections S20, S21, S22

PLATE 1

Figs. 1-6 -- Reniera Siliqua (Weller)

1, 4, 5--X 56; 2, 3--X 84

Figs. 6-9, 13, 14 -- Geodites carbonarius (Ulrich)

6, 7, 8, 14--X 56; 13--X 80

Figs. 9, 10 -- Geodites? bifurcatus

9, 10--X 51

Figs. 11, 12, 15-20 -- Geodites n. sp. (proposed)

16--X 80; 11, 18--X 84; 12--X 112;

17, 19--X 120; 15--X 160

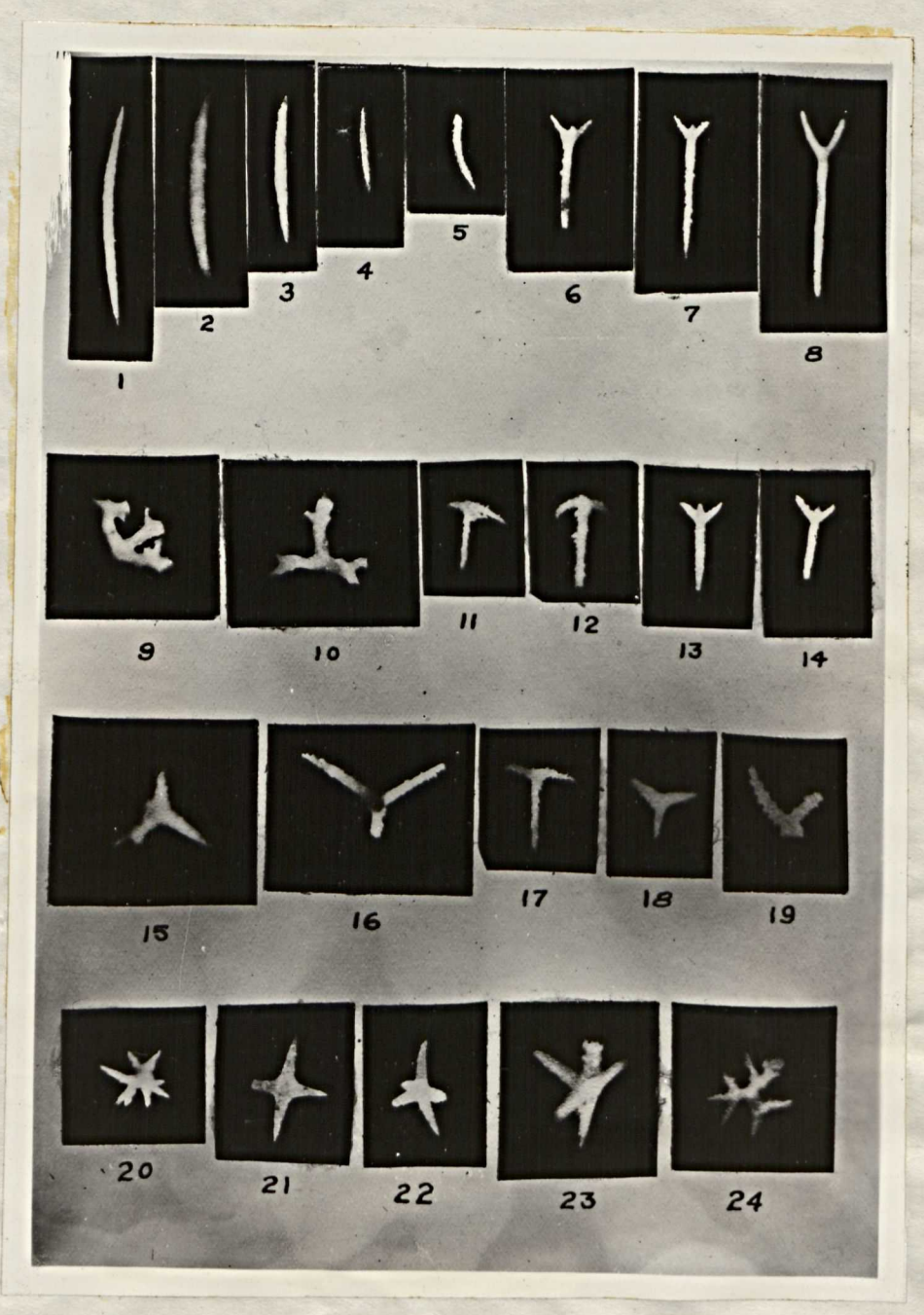
Figs. 20, 24 -- New Genus n. sp.

20--X 80; 24--C 120

Figs. 21-24 -- Suggested New Order, Genus 2, n. sp.

21, 22--X 80; 23--X 112

PLATE 1



Suggested New Order --(Pentactinellidae)

The author found numerous spicules having five rays. In the classification used for fossil sponges there is no place for such a form, unless possibly under Heteractinellidae, which would not be entirely logical when considering the names of other orders. Therefore, a new order is suggested to take care of that group of fossil sponges which five-rayed spicules.

GENUS 1 --(new)

This genus is proposed to include all forms having four head rays and a shaft ray.

Genus 1 n. sp.

Plate 2, Fig. 14, 16-19, 20

Several nearly perfect specimens of this species were observed. There are four recurved head rays, which are comparatively short and taper rapidly from their junction to sharply pointed terminations. They vary in length from .12 mm. to .36 mm. and have a maximum thickness of from .08 mm. to .12 mm. The head rays form an angle with the shaft ray of about 30 degrees. The shaft ray tapers slightly from the junction with the head rays and then terminates more or less bluntly. It varies in length from .28 mm. to 1.44 mm. and in thickness from .04 mm. to .14 mm. The surface is rough due to numerous, minute, spines sticking out normal to it.

MSM micro-paleontological collection S23, S24, S26

Genus 1 n. sp.

Plate 2, Fig. 15, 19

Only one specimen of this species was observed. Two of the head rays are broken but the remnants are easily recognizable. The head rays are slightly recurved, forming an angle with the shaft ray of about 60 degrees. They form a greater angle with the shaft ray and are longer and slenderer in proportion than the species described above. The length is .4 mm. and the thickness .06 mm. The shaft ray tapers back from the junction slightly and then ends in a blunt termination. It is 1 mm. long and .08 mm. thick at the maximum cross section. The surface of the spicule is covered with fine spines projecting at right angles to it. MSM micro-paleontological collection S24

GENUS 2 --(new)

This genus is proposed to include all spicules possessing five equally sized rays.

Genus 2 n. sp.

Plate 1, Fig. 21-24; Plate 2, Fig. 1

A considerable number of perfect spicules of this species were isolated by the author. The first impression is that they are a Hexactinellidae form with one ray broken off near the junction, however, numerous observations in an effort to note a fragment or scar of the proposed missing ray and the added fact that usually four of the rays are slightly curved while one remains straight leads the writer

to the conclusion that this is a five rayed form. The rays are of equal size and usually arranged with one straight ray in the center while the other four are in a plane normal to it. The four rays curve slightly away from the central ray (see Plate 1, Fig.22). The rays vary in length from .28 mm. to .44mm. and in maximum thickness at the junction of from .08 mm. to .1 mm. They taper from the junction to a sharp point at the termination.

MSM micro-paleontological collection S27, S28, S29, S30

Order HEXACTINELLIDA

This group includes all sponges having six rayed spicules. Usually the rays are situated nearly at right angles with each other and are of equal length. Numerous fragments of this type of spicule was observed in the material under observation by the writer.

Rhakestella alba --(J. M. Weller)

Plate 2, Fig. 7, 11, 13

Several perfect spicule forms of this species were studied. They have six equal length rays, situated at right angles to each other, which have a pronounced taper from their junction to the sharply pointed termination. The rays vary in length from .16 mm. to .52 mm. and in thickness at the junction from .02 mm. to .10 mm. The spicules are covered with very minute spines which project at right angles to the surface.

M.S.M. Micro-Paleontological Collection S21, S25, S26, S28, S30, S31, S32, S34, S35.

Hyalostellia delicatula --(Ulrich)

Plate 2, Fig. 5, 6, 8, 9, 10

This species also has six equally sized and spaced rays, but they are much longer and slenderer. They have a very gentle taper from the junction to a keen sharp termination. The length varies from .32 mm. to .60 mm. and the thickness from .01 mm. to .02 mm. The surface is covered by numerous minute spines which project at right angles to it.

M.S.M. Micro-Paleontological Collection S34, S36, S37

Spicules of Unknown Affinities

Plate 2, Fig. 2-5

These specimens may be a type of spicule and yet they present the appearance of bundles of spicules rather than an individual. This is possibly due to a fusing of spicules either in the life of the sponge or to alterations in the material after deposition in a bed. The author is of the opinion, however, that the specimens represent a definite type of sponge skeletal structure. The evidence is too meager for definite classification.

M.S.M. Micro-Paleontological Collection S38, S39

PLATE 2

Fig. 1 -- Suggested New Order, Genus 2 n. sp.

1--X 80

Figs. 2-5 -- Spicules of Unknown Affinities.

2, 3, 4--X 80

Figs. 5, 6, 8, 9, 10 -- Hyalostellia delicatula (Ulrich)

5, 6, 9, 10--X 80; 8--X 120

Figs. 7, 11, 13 -- Rhakestella alba (J. M. Weller)

7-11, 13--X 80

Fig. 12 -- Geodites n. sp. (proposed) with fragments of Genus? sp. (?)

12--X 80

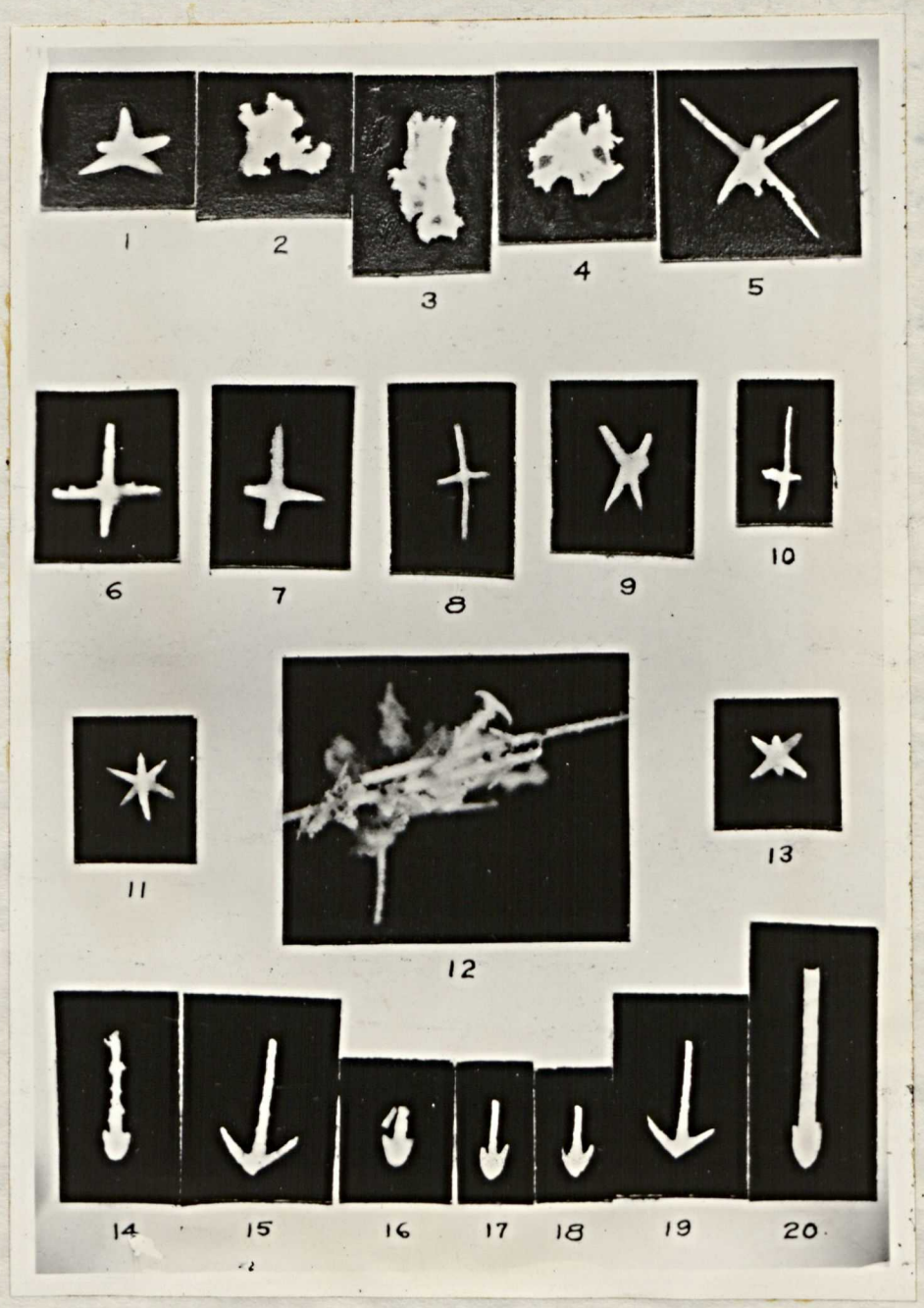
Figs. 14, 16-19, 20 -- Suggested New Order Genus 1 n. sp.

18--X 56; 17, 20--X 80; 14--X 112; 16--X 160

Figs. 15, 19 -- Suggested New Order Genus 1 n. sp.

19--X 56; 15--X 80

PLATE 2



CONCLUSIONS

The meager amount of literature and apparent inadequate classification leads to many difficulties. Nicholson and Lydekker, the earliest workers, linked the modern sponges to those of the past by means of spicules. They mention the fact that certain sponges of the order Tetractinellida have "in addition to the typical tetraxial spicules. . . . . usually other uniaxial forms." Weller remarks that, "associated with these pronged spicules (Tetractinellida, Geodites pateus) are numerous straight smooth cigar-shaped monaxons which are believed to have come from the same sponges." This leads one to wonder how many different types of spicules might come from the same sponge. Yet, with the inadequate studies of modern sponges in connection with this work, the author has been unable to make any groupings of spicules which might possibly be derived from the same sponge.

The new family (Pentactinellidae) suggested by the writer, might seem rather a broad step. Genus number one answers almost perfectly the description both in Nicholson and Lydekker, and in Weller of certain root tufts, composed of spicules. Weller associates them with the genus Hyalostellia under order Hexactinellida, but does not give an illustration. Nicholson and Lydekker give an illustration of this form. It differs from the proposed new genus in the fact that the shaft rays enlarge posteriorly, whereas those obtained by the writer taper in that

direction more or less to acute terminations. Some of them are quite similar to Geodites n. sp. (Powe) except for having an extra head ray. On this basis the writer included these forms under his proposed new order. The second genus is undoubtedly new. No scars remain or fragments of any type as an indication of a ray having been broken off of a hexactinellid form. A considerable number of complete spicule forms of this genus were isolated and many fragmentary pieces were noted.

Definite steps in the technique of removing and handling the spicules were made, but as before mentioned, the technique is still somewhat unsatisfactory.

In conclusion, the writer wishes to say that it is his firm belief that much can be done in straightening out the classification of sponges if they are studied in conjunction with modern forms. Both Mr. Powe and the author have obtained many complete and varied forms of spicules out of a few rock specimens from the Quadrant of Montana. The field for this type of work in Montana has been barely scratched and it is the hope of the author that future students of the Montana School of Mines will see fit to carry on the work.

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